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(54) Processed flax straw, its manufacture and uses

(57) Comminuted flax fibres with a fibre-length of 1-25mm are used with an agglomerating agent which is or includes the macerated, non-fibrous part (tow or shive) of whole flax straw in the manufacture of a particulate material for industrial, horticultural, agricultural or domestic end-uses. The comminuted fibres, prepared in e.g. an horizontal hammer mill and ranging in average length towards 3-6mm dependent on the intended end-use, are pelleted in intimate admixture with the macerated tow e.g. by extrusion and resultant gelatinization of the tow through a die and severance of the emergent rods into either disc-like or rod-like pellets. They find use as a soil-stabilizer, as a feed supplement supplying necessary roughage for ruminant animals, as toilet litter for domestic animals, as absorbent for industrial or other oil-spillages etc, as a persistent, slow-release particulate solid lubricant e.g. in oil-rigs or other underwater locations.

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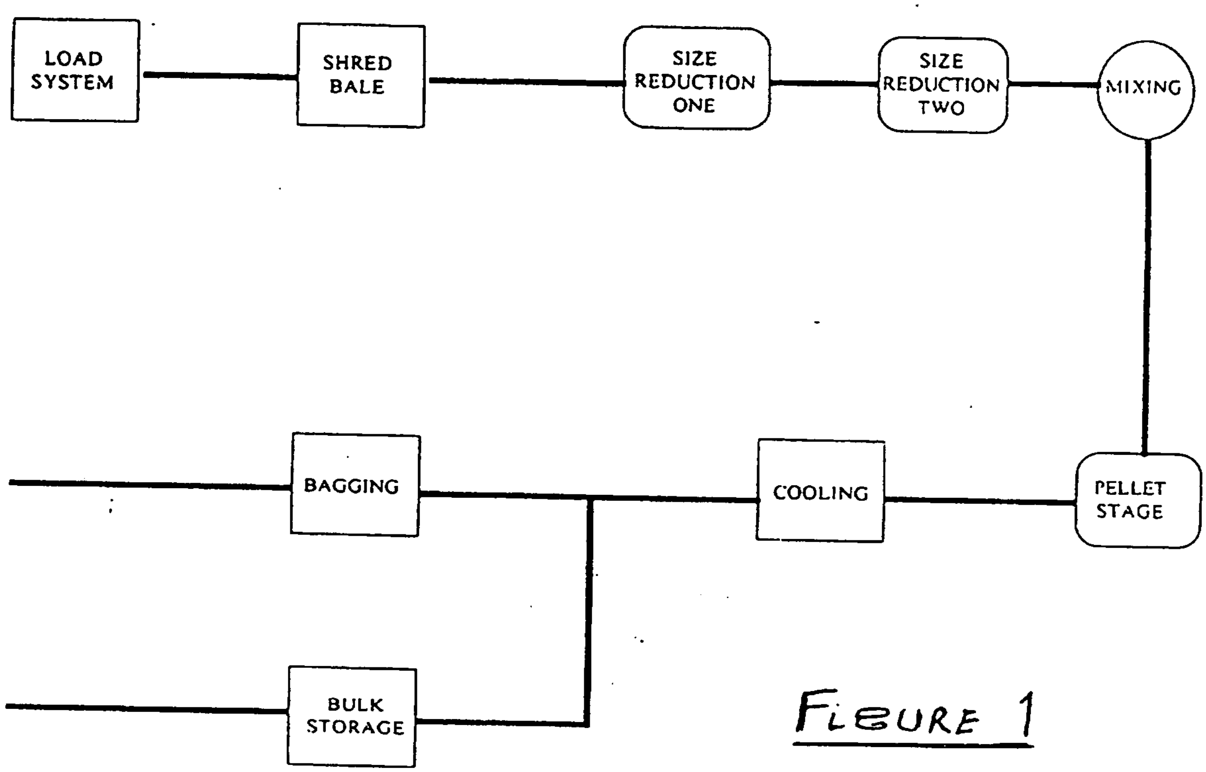
LOAD SYSTEM
SHRED BALE
SIZE REDUCTION ONE
SIZE REDUCTION TWO
MIXING
PELLET STAGE
COOLING
BAGGING
BULK STORAGE

FIGURE 1

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PROCESSED FLAX STRAW, ITS MANUFACTURE AND USES

This invention concerns processed flax straw, as well as its manufacture and uses. More particularly it relates to products based on comminuted whole flax straw, the manufacture of such products usually in pelletized or other particulate form, and the use of these products in a wide variety of industrial, horticultural and agricultural including animal husbandry applications, even indeed for certain domestic purposes.

Flax is a crop grown since antiquity for its value as the source of linen fibre, and in turn linen thread and cloth; and indeed it is still today highly prized for that purpose. However, linen fibre competes with other, cheaper textile fibres, both natural and synthetic, for use in the manufacture of textile fabrics, and its market as a textile fibre though large is nevertheless limited by the fairly small share at the luxury end of the overall textile market which is held by linen.

The species of flaxplant **linum usitatissimum** grown for conversion into textile fabrics is long-stemmed to provide maximum fibre length, and the agricultural industry and its mentors seek to set annual production targets for that long-stemmed variety of flaxplant which so far as possible coincide with expected annual consumption by the textile

industry.

It will also be understood that when processing flax straw some of the fibres, either by their very nature or by rupture in the processing itself, emerge as too short for textile use and are discarded for that purpose. There are industrial uses for these underlength fibres, e.g. in the paper industry, in geotextiles, in the civil engineering and construction industries and in bio-plastics. Nevertheless the overall waste problem is still exacerbated by the need to dispose of the residues left over from the processing of the flax straw into linen fibres.

The seed of a cultivar of the flaxplant, commonly called linseed, has become recognized as a valuable source of the vegetable oil commonly called linseed oil. This is a drying oil, that is to say it has film-forming properties when exposed to oxidation in the air, and it has long been used as an ingredient of conventional oil paints. Nowadays linseed oil finds a variety of other industrial applications, e.g. in the manufacture of linoleum floor-coverings.

The varieties of the flaxplant chosen for linseed oil production are however those which give the highest yields of seed, and have tended to have shorter stalk-lengths than fibre flax varieties making them less suitable (though not wholly unsuitable) for use in the manufacture of linen

fibre. It has been estimated that currently some 95% or more of worldwide flax crops are grown for linseed rather than for textile fibre, and the specialist market for linen production is usually well-supplied with purpose-grown flax straw of the more appropriate varieties.

Burning flax straw is as unacceptable as burning wheat or other cereal straws; and, while cereal straws can be ploughed into the ground after the crop has been harvested, this can be very hard to achieve with flax straw due to the great strength and length of the flax fibre, which is not readily ruptured and therefore tends to ball-up on the ploughshare and be dragged through the ground thereby, rather than interred therein.

Thus it can be seen that, whether involved in growing long-stemmed varieties of flax for use in textile-production or short-stemmed varieties for use in linseed-oil production, one is always faced with some kind of waste problem, arising from the need to utilize or dispose of (a) the so-called "tow" and "shrives" left over from fibre processors, and/or (b) any excess production of long-stemmed flax plants, as well as (c) the short-stemmed flax-straw generated in linseed oil production.

These days the objective must be to make flax a true agrorefinery crop, that is to say one with which the whole plant can be utilized - and it is an objective which we

believe to be attainable. As a step in that direction new "dual purpose" varieties of the flax plant are already under development, which strive to be good sources of both fibre for the production of linen and of linseed for the production of linseed oil. However, given the imbalance between the quantities of flax grown for linen production and for linseed production, such efforts even when successful can be only a palliative.

Of course, this waste-disposal (or waste-utilization) problem has already been recognized, and attempts have been made to find uses for flax straw. It has for instance already found some use in horticulture and also in the manufacture of furniture, plastics and other industrial products. These efforts however have so far met with relatively little success, and the long-standing need for a comprehensive answer to the flax-waste problem still cries out for an adequate solution.

The perception which has given rise to the present invention is that the industries potentially interested in use of flax straw as a raw material can adopt it only if assured of a regular and reliable supply of a semi-processed product which is of consistent and reliable quality and in a form which can be readily and economically handled without any need for specialized machinery. We have moreover explored the possibilities that spring from

that perception, and after careful investigations and much trial and error we have established the parameters which we believe govern how flax straw needs to be semi-processed if it is to be an easily-handled product of consistent quality capable of use either directly for some purposes or indirectly as a raw material for other, quite diverse industrial manufacturing operations. And we have furthermore come to realize that the processed flax straw thus developed opens up the possibility of its employment in new ways in horticulture, agriculture (including animal husbandry) and even the domestic environment.

According to this invention, in its broadest aspect, there is therefore provided the use of comminuted flax fibre having a fibre length within the overall range of from 1 mm to 25 mm, and preferably from 3 mm to 20 mm, together with an agglomerating agent, in the manufacture of a particulate material for industrial, horticultural, agricultural or domestic end-use(s).

As will appear better hereinafter, this novel use for flax involves manufacturing a near-homogeneous mixture of the fibres and the agglomerating agent and compressing that mixture into coherent but friable discrete particles of at least partly uniform size and shape, most conveniently by extrusion into the form of pellets of uniform shape and size in at least two dimensions.

In another aspect this invention provides a particulate material comprising an intimate mixture of comminuted flax fibres having at least 90% thereof with a fibre length within $\pm$ 10% of the average fibre length of said fibres, said average fibre length lying within the range of from 1 mm to 25 mm, and preferably from 3 mm to 20 mm, together with an agglomerating agent, said mixture being formed into discrete coherent but friable particles of substantially uniform size and shape.

The particulate material thus formed is a new industrial product which consistently supplies flax fibres of near-enough uniform, predetermined length, within the range of from 1 mm to 25 mm, and preferably from 3 mm to 20 mm, and thus suitable for a wide range of potential industrial or other applications. The choice of any particular average fibre length can be made for optimum effectiveness in any particular use envisaged for the product.

It is of course the flax fibres that are the basic component of this product, but the agglomerating agent is necessary to enable the fibres to be formed into the desired discrete, coherent particles, and must be present in a proportion sufficient to ensure that the particles are indeed coherent, and will withstand normal handling.

It is however also necessary that the particles should

be friable, so that they can be broken down to release the fibres to serve their ultimate function whatever that may be - and consequently the nature and the proportion of agglomerating agent employed should be not so great as to seriously resist mechanical break-down and/or chemical or biological degradation to release the fibres when required.

It is not possible to lay down any general rule as to the proportion of agglomerating agent that should be used, since the necessary minimum to secure coherence is dependent upon both the average fibre length and the nature of the agglomerating agent employed. It is however well within the competence of those accustomed to the preparation of pellet-style products to determine the minimum, optimum and maximum proportions of any particular agglomerating agent when employed with fibres of any particular average length and provenance. As regards the provenance of the comminuted flax straw, it may be borne in mind that there may be differences between the behaviour of fibres deriving from one variety of flax plant or another, though usually in our experience any such differences are relatively small.

While it is recognized that for certain possible industrial uses of the semi-processed product it may be desirable to select agglomerating agents for the fibre which are of a specialized nature, and the use of such

specialized agglomerating agents is within the scope of this invention, nevertheless it is a happy accident that we have found that the non-fibrous part of flax straw (i.e. the outer bark and the inner pith of the flaxplant) when macerated into a near-homogeneous meal is excellently suited when moistened and heated by steam to gelatinize and in this gelatinized form to serve as an agglomerating agent which enables the fibre and gelatinized meal mixture to be formed into adequately-coherent but still friable pellets or the like, and moreover being biodegradable the dried meal is particularly suitable for certain purposes which are currently of interest, as will be explained hereinafter.

Thus it is a preferred feature of this invention that the agglomerating agent which is mixed in with the comminuted flax-fibres should consist of or include the macerated, non-fibrous part of whole flax straw.

According to another aspect of this invention there is also provided a process for the manufacture of a particulate material containing comminuted flax fibre agglomerated into discrete particles, suitable as a source of consistent-quality flax fibre for industrial or other use, in which:

- flax fibre derived directly or indirectly from harvested flax straw is comminuted to achieve an average

comminuted fibre length in the range of from 1 mm to 25 mm, and preferably 3 mm to 20 mm;

- the comminuted flax fibre thus secured is intimately and near-homogenously mixed with an agglomerating agent; and

- the mixture is compressed and formed into discrete particles which are sufficiently coherent to withstand normal handling but still friable enough to be capable of breakdown to yield the comminuted flax fibre to serve its ultimate function.

The flax fibre employed as starting material in this process obviously must derive from harvested flax straw (no matter whether a long-stemmed or a short-stemmed variety of flaxplant) and may do so directly if one chooses to feed flax straw as such to the comminutor employed - which for some purposes is desirable, especially where the non-fibrous part of the flax straw is to be simultaneously macerated and then to serve as the agglomerating agent. This technique is especially appropriate when processing flax straw left over from linseed oil production.

However, the flax fibre employed may also be derived indirectly from the harvested flax straw, e.g. after retting, or indeed also from residues of shorter-length flax fibres (known as tow) generated during the mechanical scutching operation performed on the flax fibre during

manufacture of textile-grade linen fibre, thread and cloth.

Comminution may be achieved by any method which will achieve an average fibre length in the range of from 1 mm to 25 mm, and preferably from 3 mm to 20 mm, but obviously there are practical handling problems and one should choose the method which is most convenient to operate and therefore cost-effective, since one is here operating on low-value but very strong material and cannot afford too high a processing cost per unit of throughput. After a variety of investigations we have satisfied ourselves that comminution to the desired fibre length is usually best performed in a percussion mill, above all in an horizontal hammer mill.

Of course the comminution may be performed in stages, and before final comminution to the desired fibre length it is possible, and in our experience usually advantageous, first to subject the flax-straw or other flax fibre to a preliminary fibre-shortening stage by chopping or grinding it to an intermediate length, e.g. in a Swiss Combi tub-grinder or a rotating knife chopper, to a straw-length in the range of from 3 cm to 6 cm.

The average fibre length of the comminuted flax fibre, and the spread of fibres having an individual fibre length which departs (either upwards or downwards) from that average, can be readily estimated, with an accuracy

sufficient for the purposes of this invention, by progressive sifting of the comminutor-output and weighing the thus-separated fractions.

When preparing final products for horticultural or agricultural use, as will be described subsequently, the near-uniformity of fibre length is usually not so important as it can be when preparing final products for industrial use, where consistently-repeatable quality is usually vital, and the additional cost of securing a near-uniform fibre length can therefore be justified.

Especially for that last mentioned purpose it is therefore an optional and but often preferred feature of this invention that the process includes the step, after comminution but before mixing the comminuted fibre with the agglomerating agent, of segregating the comminuted flax fibre according to length, and separating the segregated fraction wherein at least 90% (by weight) of the individual fibres have a length within ± 10% of the average fibre length, and thereafter employing that separated fraction for admixture with the agglomerating agent.

The target range for fibre length of from 1 mm to 25 mm, and preferably from 3 mm to 20 mm, has been carefully and empirically selected to achieve the purposes of this invention.

On the one hand, when the average fibre length is

below 1 mm we have found that the pellet-type product does not have a coherence (at any rate when employing the desired lower proportions of the kind of agglomerating agent which we prefer to use) adequate to withstand normal handling; and the contribution of the fibre to coherence is fairly marginal until the average fibre length is 3 mm or more. From the viewpoint of the overall agrorefinery objective, it is worth mention that anyway there is an already-established market for flax fibres with a very short average fibre length in the papermaking industry.

On the other hand, when the average fibre length is above 25 mm we have found that the fibres tend excessively to matt together and the task of near-homogenously mixing the fibre with the agglomerating agent and thereafter forming the mixture into pellet-type products becomes so difficult to achieve with conventional machinery that coherent pellet-type products of reasonably consistent quality cannot be reliably secured. It is moreover only when the average fibre length is no more than 20 mm that these problems can be handled conveniently.

Within the specified fibre-length range of from 1 mm to 25 mm, and preferably from 3 mm to 20 mm, the objectives of the invention can be attained. The desired dual qualities of coherence and friability are generally-speaking best obtained when the average fibre length is in

the narrower range of from 6 mm to 16 mm. There may however be other considerations besides coherence and friability that to some extent dictate the average fibre length to be employed, springing usually from the end-use envisaged for the semi-processed product and the economic factors that apply to that end-use.

On the whole, the employment of shorter fibre lengths, e.g. from 3 mm (and preferably 4 mm) up to 6 mm, is usually advantageous in pellet-type products destined for an industrial end-use, whereas the employment of longer fibre lengths, e.g. from 10 mm up to 20 mm and preferably 14-16 mm, is usually advisable in products destined for an horticultural or agricultural end-use.

The formation of the mixture into discrete particles can be effected by any operation designed for that purpose, which however will necessarily involve some element of compression and usually also shaping of the mixture into an at least partly (and often wholly) pre-set size and shape. It is possible for this purpose to envisage the use of die-and-plunger arrangements or the use of cavity-surfaced rollers (or even plain rollers, if complete uniformity of shape is not important), but we believe that for various reasons of economy and effectiveness it is generally best to employ a continuously-operative extrusion die and a guillotine associated with the exit port(s) thereof, e.g.

an axially-fed, apertured extrusion cylinder powered by an eccentrically-mounted internal rotating drive member in conjunction with an external guillotine blade rotating synchronously with that drive member.

If, as will normally be the case, the extrusion apertures in the cylindrical die are themselves circular in cross-section the mixture will be extruded therefrom (at a rate determined by the extrusion pressure employed and the fluidity of the mixture) emerging as rods having a length determined by the speed of extrusion and rate of rotation of the guillotine blade. It is perhaps worth mention that in its axial direction, from the entry port to the exit port, the die will be first tapered inwardly to increase the extrusion pressure, and then reverse-tapered outwardly to facilitate release of the pellet as it is severed by the guillotine blade. Thus one can, as desired, form either at one extreme very short "rods" (having a length in the axial direction even perhaps less than the diameter of the rod, and then more like discs) or at the other extreme quite long rods (having an axial length several times greater than the diameter thereof) as desired.

As a generalization, we believe that short rods or discs are usually best for an industrial end-use, whereas for at least one now-envisaged horticultural use longer rods are to be preferred, as will be further described

subsequently. Whatever the exact shape of such extruded products (whether rods or discs) they are here referred to generically as "pellets".

However much the industrial use of flax fibre can be promoted or developed by the preparation and employment of the new particulate material hereinbefore disclosed it is clear that, for at least the foreseeable future, there is likely to be an excess of the available supply of flax fibre over the industrial demand for it. We have therefore sought for and now developed new uses for flax fibre, in the form of the particulate material of this invention, in the horticultural/agricultural, animal husbandry and domestic environments.

In accordance with one still further aspect of this invention there is also provided a method of improving and/or stabilizing soil in which an area of soil to be improved and/or stabilized against wind and/or water erosion is treated by applying thereto an appropriate amount of the particulate material herein disclosed.

Since at least the flax fibre component of the particulate material is slowly bio-degradable this treatment will improve the soil's nutritive value by promoting humus therein, and (usually more importantly, even in or on poor soil) the particulate material while it undergoes slow biodegradation will provide ground cover

which simultaneously serves as a mulch to restrain the growth of unwanted plants and conserve moisture in dry soil as well as also to form a matting of flax fibres which helps to reduce the velocity (and thus the erosive action) of both wind and run-off water, especially on sloping ground.

Indeed, one of the chief uses now envisaged for this kind of soil treatment is in the stabilization and betterment of road and rail embankments and the like. Thus for instance the particulate material of this invention may be projected by any convenient means (e.g. by spewing from an ejection nozzle under pneumatic propulsion) in a stream directed towards a newly-created embankment so as to build up a loose surface-blanketing layer of the particulate material upon that embankment.

In the case of all the soil treatments so far envisaged it currently appears to us that the longer-rod forms of particulate material are especially desirable, and indeed particularly those containing longer-length flax fibres. Aside from commercial considerations, this preference is founded upon the fact that even on level ground the longer flax fibre lengths are more inclined to matt together and less inclined to wash away, while moreover upon steeply-sloping ground such as embankments the longer rods are much less likely to tumble downwards

under the influence of gravity.

Where the particulate material of this invention is intended for soil improvement and/or stabilization it may sometimes advantageously also include plant nutrients and/or grass seed. It is also regarded as desirable for this kind of end-use that the agglomerating agent should consist of or at least include the macerated bark and pith of whole flax straw.

According to yet another preferred feature of this invention there is also provided a method of animal husbandry in which ruminant livestock are fed with a nutritive feedstuff containing the flax-fibre-containing particulate material herein disclosed in a proportion such as to supply some or all of the roughage necessary for the digestive well-being of the ruminant animal thus fed.

Here again, but in this case mainly for economic reasons, we consider that the longer fibre, longer rod type of particulate material is to be preferred. Moreover for this kind of end-use it is desirable, both for economic and nutritive reasons, that the agglomerating agent should consist of or at least include the macerated bark and pith of whole flax straw. And for nutritive reasons the agglomerating agent employed may also include other animal nutrients, and specifically for instance crushed linseed oil-cake (already employed as an animal feedstuff) which is

a by-product from the manufacture of linseed oil.

In a variant of the method of animal husbandry described above, there is provided a procedure wherein ruminant and/or non-ruminant livestock are fed with nutritionally-enhanced feedstuff containing the particulate material aforesaid wherein the cellulosic content of said flax-fibre has been at least partially degraded into more digestible form by treatment with strong alkali.

This procedure in itself is known for the treatment of cereal straws, and therefore does not need to be further described in detail. It is however worth mention that the preliminary treatment of the flax fibre to partially degrade the cellulose and thereby enhance the nutritional value of the fibre can most conveniently be effected by incorporating strong alkali e.g. sodium hydroxide (NaOH) into the fibre and tow mix fed to the pelleting operation, which is brought to reaction with the cellulosic content of said fibre by the heat and pressure generated during pelleting.

According to yet another feature of this invention there is provided the use of the flax-fibre-containing particulate material of this invention as litter for domestic animals, especially cats.

In use as cat &c. litter the particulate material will be very desirably take the form of minuscule pelleted

rodlets having a diameter not exceeding 3 mm and an average length not exceeding 6 mm. As thus prepared the particulate material has a very large ratio of surface area to volume, and being highly absorbent makes a most-excellent litter-material, and since it is totally organic is entirely suitable for composting or similar garden disposal (unlike conventional litters based on china clay) or for landfill purposes.

According to a still further aspect of this invention, there is also provided the use of the flax fibre-containing particulate material of this invention as an absorbent for industrial oil spillages.

Here again it is desirable to employ the particulate material in the form of miniscule pelleted rodlets having a diameter not exceeding 3 mm and an average length not exceeding 6 mm so as to maximise the ratio of surface area to volume. The absorbency of the particulate material coupled with its lipophilic character makes it highly suitable for mopping up oil and other spillages in workplaces such as garages, filling station forecourts and industrial installations.

After such use oil-contaminated particulate material may be safely disposed of by combustion in a suitable furnace. It is however also suitable for use as a particulate solid lubricant, as envisaged below.

According to a still further feature of this invention there is also provided the use of the flax-fibre-containing particulate material of this invention, with or without additional lubricant oils absorbed therein, as a particulate, solid lubricant material for use as a persistent, slow-release lubricant wherever such is required, e.g. in the off-shore oil industry.

The relatively abrasion-resistant nature of the cellulosic flax-fibre coupled with its lipophilic character and residual content of linseed oil together render the flax-fibre-containing particulate material of this invention ideal for use as a long-lasting, slow-release lubricant material, particularly suited for underwater applications because the innate oil-content of the flax fibre is retained therein by physico-chemical bonding, so that even when submerged in fresh or sea water there is little danger of any significant leaching out of the linseed (or indeed any other) oil.

When the innate oil-content of the flax fibre is supplemented with additional oil (e.g. the contaminating oil derived from mopping-up industrial oil spillages, as envisaged above) the additional oil thus absorbed into the flax pellets is retained perhaps less strongly, but nevertheless sufficiently strongly to serve an useful purpose.

In order that the invention may be well understood one preferred procedure will now be described in more detail, though only by way of illustration, with reference to the accompanying drawings, in which:

Figure 1 is a schematic flow-diagram showing the path taken by whole flax straw as it is processed through the factory into a comminuted flax fibre.

As will be seen from Figure 1, baled flax straw (in the case of linseed straw after harvesting the linseed) arrives at a loading and feeding system which breaks down the bale into loose straw, ready for subsequent processing. Specifically, each bale is first fed to the "Load System" station (1) where it is burst open, and then passed to a bale-shredder at the "Shred Bale" station (2).

The loose flax straw then goes forward to the "Size-Reduction One" station (3), where the straw is chopped and/or ground to reduce its length until the flax straw emergent from this preliminary size-reduction has a length of the order of 3 to 10 cm. Specifically one can for this purpose pass the straw through a series of rotating knives, utilizing for instance a modified Tarrup forage harvester system.

At this point it should be said that it is alternatively possible to combine the bale-shredding and preliminary size-reduction operations at stations (2) and

(3) by utilizing a farmhand tub grinder. This machine has a 2.5 metre tapered round hopper, which is 1.5 metres deep and is arranged to rotate around a fixed base through which the hammers of a horizontal hammer will project in operation. When operative, the hammers will draw the straw into the mill, where the straw will be hammered through an integrale semicircular screen. The screen size can be varied from 1/2" diameter to 4" diameter, and will be adjusted to achieve the desired straw length of roughly 3 cm (about 1.2 inches) up to 10 cm (about 4 inches). The number of hammers employed ranges from 48 to 96; and the hammers have a clearance of 1.5mm from the screens.

Whichever of these alternative measures is adopted to achieve the preliminary size-reduction, the reduced-length flax straw emergent from station (3) is then passed on, for final comminution, to the "Size-Reduction Two" station (4). It is there processed until its average fibre length is approximately the desired value, predetermined according to the end-use envisaged. We have at this stage used a Christy X26 hammer mill, with a power rating of 93kW, to reduce the straw/fibre to an average length of 3 mm, but the parameters of the operation can of course be adjusted to yield average straw/fibre lengths anywhere in range of from 1 to 25 mm.

The comminuted flax straw from station (4), which now

has the consistency of meal, is then passed (either continuously or batchwise according to the arrangement employed) to the "Mixing Station" (5). At this stage we employ a 2 tonne horizontal multi-bladed mixer with a power rating of 37kW. Any necessary agglomerating agents and/or other optional or desirable solid or liquid ingredients of the final product can be added at this stage, e.g. flavours or flavour-enhancers.

The mixture of fibre and agglomerating agent emergent from "Mixing Station" (5) is then fed into any suitable pelleter at the "Pellet-Stage" station (6). We prefer to employ a pelleter in the form of an apertured cylinder driven by an eccentrically-mounted internal rotor impeller and an externally-mounted guillotine blade rotated synchronously with the impeller rotor. Specifically we have employed a California Meal Press, model SP6, with a power rating of 93kW. Steam at a temperature of 115°C was introduced in order to moisten and heat the meal to a temperature of 65°C, thereby at least partly gelatinizing it. The semi-gelatinized meal was extruded through tapered 6 mm dies, with a die length of 105 mm.

The desired pelleted product emerges from the tapered circular extrusion apertures in rod-form, each rod having a length dependent on the fluidity of the mixture, the extrusion pressure applied to the mixture and the speed of

rotation of the guillotine blade.

The emergent pellets are at elevated temperature, due not only to the steam-heating but also to the heat frictionally generated by the extrusion. These pellets are therefore finally cooled at the "Cooling Station" (7), for instance by passage through a Miltech 1 tonne capacity counterflow cooler.

Once cooled to ambient temperature, the pellets thus produced are sent finally either to a "Bagging Station" (8) or to a "Bulk-Storage Station" (9).

CLAIMS

1. The use of communited flax fibres having a fibre length within the range of from 1 mm to 25 mm together with an agglomerating agent in the manufacture of a particulate material for industrial, horticultural, agricultural (including animal husbandry) or domestic end-use.

2. Use as claimed in claim 1, in which a near-homogeneous mixture of fibres having an average fibre length within the range of from 3 mm to 20 mm together with agglomerating agent is manufactured by compression into coherent but friable discrete particles of at least partly uniform size and shape.

3. Use as claimed in claim 2, in which the mixture is compressed by extrusion into the form of pellets of uniform shape and size in at least two dimensions.

4. A particulate material comprising an intimate mixture of comminuted flax fibres having an average fibre length lying within the range of from 1 mm to 25 mm, together with an agglomerating agent, said mixture being formed into discrete, coherent but friable particles of near-uniform size and shape.

5. A particulate material as claimed in claim 4, in which the average fibre length lies in the range of from 3 mm to 20 mm.

6. A particulate material as claimed in claim 4 or claim 5, primarily for an industrial end-use, in which the average fibre length lies within the range of from 3 mm to 6 mm.

7. A particulate material as claimed in claim 6, in which the average fibre length lies within the range of from 4 mm to 6 mm, and at least 90% by weight of the fibres have a length within ± 10% of that average fibre length.

8. A particulate material as claimed in claim 4, primarily for an horticultural, agricultural, animal husbandry or domestic end-use, in which the average fibre length lies within the range of from 10 mm to 20 mm.

9. A particulate material as claimed in claim 8, in which the average fibre length lies within the range of from 14 mm to 16 mm.

10. A particulate material as claimed in claim 8 or claim 9, in which the agglomerating agent mixed in with the comminuted flax-fibres is or includes the macerated, non-fibrous part of freshly-harvested, whole flax straw.

11. A process for the manufacture of a particulate material containing comminuted flax fibre agglomerated into discrete particles, suitable as a source of consistent-quality flax fibre for industrial or other use, in which:

-flax fibre derived directly or indirectly from harvested flax straw is comminuted to achieve an average

comminuted fibre length in the range of from 1 to 25 mm;

-the comminuted flax fibre thus secured is intimately and near-homogenously mixed with an agglomerating agent; and

-the mixture is compressed and formed into discrete particles which are sufficiently coherent to withstand normal handling but still friable enough to be capable of breakdown to yield the comminuted flax fibre to serve its ultimate function.

12. A process as claimed in claim 11, in which the flax fibre is comminuted to achieve an average fibre length in the range of from 3 mm to 20 mm.

13. A process as claimed in claim 11 or claim 12, in which comminution to the desired fibre length is performed in a percussion mill.

14. A process claimed in claim 13, in which comminution is performed in an horizontal hammer mill.

15. A process as claimed in any of claims 11 to 14, in which before final comminution to the desired fibre length the flax-straw or other flax fibre is subjected to a preliminary fibre-shortening operation by chopping or grinding it to an intermediate length in the range of from 3 cm to 6 cm.

16. A process as claimed in any of claims 11 to 15, which includes the step, after comminution but before mixing the

comminuted fibre with the agglomerating agent, of segregating the comminuted flax fibre according to length, and separating the segregated fraction wherein at least 90% (by weight) of the individual fibres have a length within $\pm$ 10% of the average fibre length, and thereafter employing that separated fraction for admixture with the agglomerating agent.

17. A process as claimed in any of claims 11 to 16, in which the flax fibre employed as starting material at least partly derives indirectly from harvested flax straw, after retting and/or scutching thereof.

18. A process claimed in claim 17, in which the flax fibres employed are or include the tow and/or shrives generated during scutching.

19. A process as claimed in any of claims 11 to 18, in which the average fibre length of the comminuted flax fibre is in the range of from 3 mm to 6 mm.

20. A process as claimed in claim 19, in which the average fibre length is in the range of from 4 mm to 6 mm.

21. A process as claimed in any of claims 11 to 20, in which the flax fibre employed as starting material at least partly derives directly from harvested flax straw fed as such to the comminutor employed, and the thereby-macerated non-fibrous part of the flax straw after gelatinization serves as at least part of the agglomerating agent.

22. A process as claimed in claim 21, in which the average fibre length of the comminuted flax fibre is in the range of from 10 mm to 20 mm.

23. A process as claimed in claim 21 or claim 22, in which the average fibre length is in the range of from 10 mm to 16 mm.

24. A process as claimed in claim 23, in which the average fibre length is in the range of from 14 mm to 15 mm.

25. A process as claimed in any of claims 11 to 24, in which the mixture is formed into discrete particles of at least partly predetermined size and shape by compressing and extruding it through an extrusion die and severing the extruded rods as they emerge to a desired length by means of a guillotine.

26. A process as claimed in claim 25, in which the rate of extrusion of the mixture and the intervals at which the emergent rods are severed are adjusted relative to each other so as to yield disc-like pellets suitable for an industrial end-use.

27. A process as claimed in claim 25, in which the rate of extrusion of the mixture and the intervals at which the emergent rods are severed are adjusted relative to each other so as to yield rod-like pellets for an horticultural, agricultural, animal husbandry or domestic end-use.

28. A particulate material whenever manufactured by a

process as claimed in any of claims 11 to 27.

29. A method of improving and/or stabilizing soil in which an area of soil to be improved and/or stabilized against wind and/or water erosion is treated by applying thereto an appropriate amount of the particulate material claimed in any of claims 4 to 10 or 28.

30. A method as claimed in claim 29, in which the particulate material contains comminuted flax fibres having an average fibre length in the range of from 10 mm to 20 mm and has been compressed and shaped into rod-like pellets.

31. A method as claimed in claim 29 or claim 30, in which the particulate material also incorporates plant nutrients and/or grass seed.

32. A method as claimed in any of claims 29 to 31, in which the agglomerating agent in the particulate material is or includes the macerated bark and pith of whole flax straw, gelatinized by application of heat and moisture.

33. A method of animal husbandry in which ruminant livestock are fed with a nutritive feedstuff including flax-fibre-containing particulate material, as claimed in any of claims 4 to 10 or 28, in a proportion such as to supply some or all of the roughage necessary for the digestive well-being of the ruminant animal thus fed.

34. A method as claimed in claim 33, in which the particulate material contains comminuted flax fibres having

an average fibre length in the range of from 10 mm to 20 mm and has been compressed and shaped into rod-like pellets.

35. A method as claimed in claim 33 or claim 34, in which the agglomerating agent mixed in with the particulate material is or includes the macerated bark and pith of whole flax straw, gelatinized by application of heat and moisture.

36. A method as claimed in any of claims 33 to 35, in which the particulate material also incorporates nutrients for ruminant-livestock.

37. A method as claimed in claims 35 and 36, in which the agglomerating agent is or includes crushed linseed oil-cake.

38. A method as claimed in any of claims 33 to 37, in which the agglomerating agent is or includes tow residues recovered from scutching flax straw, said tow residues being contaminated with traces of a drying vegetable oil.

39. A method as claimed in claim 38, in which the tow residues are contaminated with raw linseed oil.

40. A method of animal husbandry in which ruminant and/or non-ruminant livestock are fed with a nutritionally-enhanced feedstuff including the flax fibre-containing particulate material, as claimed in any of claims 4 to 10 or claim 28, wherein the cellulosic content of said flax-

fibre has been at least partially degraded into more digestible form by treatment with strong alkali.

41. A method as claimed in claim 40, in which the preliminary treatment of the flax fibre to partially degrade the cellulose and thereby enchance the nutritional value of the fibre is effected by incorporating strong alkali into the fibre and tow mix fed to the pelleting operation.

42. The use of the flax-fibre-containing particulate material claimed in any of claims 4 to 10 or claim 28 as toilet litter for domestic animals.

43. Use as claimed in claim 42 in which the particulate material takes the form of miniscule pelleted rodlets having a diameter not exceeding 3 mm and an average length not exceeding 6 mm.

44. The use of the flax-fibre-containing particulate material claimed in any of claims 4 to 10 or claim 28 as an absorbent for industrial oil spillages.

45. Use as claimed in claim 44, in which the particulate material is employed in the form of miniscule pelleted rodlets having a diameter not exceeding 3 mm and an average length not exceeding 6 mm.

46. The use of the flax-fibre-containing particulate material claimed in any of the claims 4 to 10 or claim 28 as a persistent, slow-release particulate solid lubricant.

Amendments to the claims have been filed as follows

1. The use of comminuted flax fibres having a fibre length within the range of from 1 mm to 25 mm together with an agglomerating agent which is or includes the macerated, non-fibrous part of harvested, whole flax straw in the manufacture of a particulate material for industrial, horticultural, agricultural (including animal husbandry) or domestic end-use.

2. Use as claimed in claim 1, in which a near-homogeneous mixture of fibres having an average fibre length within the range of from 3 mm to 20 mm together with the agglomerating agent is manufactured by compression into coherent but friable discrete particles of at least partly uniform size and shape.

3. Use as claimed in claim 2, in which the mixture is compressed by extrusion into the form of pellets of uniform shape and size in at least two dimensions.

4. A particulate material comprising an intimate mixture of comminuted flax fibres having an average fibre length lying within the range of from 1 mm to 25 mm, together with an agglomerating agent which is or includes the macerated, non-fibrous part of harvested, whole flax straw, said mixture being formed into discrete, coherent but friable particles of near-uniform size and shape.

5. A particulate material as claimed in claim 4, in which the average fibre length lies in the range of from 3 mm to 20 mm.

6. A particulate material as claimed in claim 4 or claim 5. primarily for an industrial end-use, in which the average fibre length lies within the range of from 3 mm to 6 mm.

7. A particulate material as claimed in claim 6, in which the average fibre length lies within the range of from 4 mm to 6 mm, and at least 90% by weight of the fibres have a length within $\pm$ 10% of that average fibre length.

8. A particulate material as claimed in claim 4, primarily for an horticultural, agricultural, animal husbandry or domestic end-use, in which the average fibre length lies within the range of from 10 mm to 20 mm.

9. A particulate material as claimed in claim 8, in which the average fibre length lies within the range of from 14 mm to 16 mm.

10. A process for the manufacture of a particulate material containing comminuted flax fibre agglomerated into discrete particles, suitable as a source of consistent-quality flax fibre for industrial or other use, in which:

-flax fibre derived directly or indirectly from harvested flax straw is comminuted to achieve an average comminuted fibre length in the range of from 1 to 25 mm;

-the comminuted flax fibre thus secured is intimately and near-homogenously mixed with an agglomerating agent which is or includes the macerated, non-fibrous part of harvested, whole flax straw; and

-the mixture is compressed and formed into discrete particles which are sufficiently coherent to withstand normal handling but still friable enough to be capable of breakdown to yield the comminuted flax fibre to serve its ultimate function.

11. A process as claimed in claim 10, in which the flax fibre is comminuted to achieve an average fibre length in the range of from 3 mm to 20 mm.

12. A process as claimed in claim 10 or claim 11, in which comminution to the desired fibre length is performed in a percussion mill.

13. A process claimed in claim 12, in which comminution is performed in an horizontal hammer mill.

14. A process as claimed in any of claims 10 to 13, in which before final comminution to the desired fibre length the flax-straw or other flax fibre is subjected to a preliminary fibre-shortening operation by chopping or grinding it to an intermediate length in the range of from 3 cm to 6 cm.

15. A process as claimed in any of claims 10 to 14, which includes the step, after comminution but before mixing the

comminuted fibre with the agglomerating agent, of segregating the comminuted flax fibre according to length, and separating the segregated fraction wherein at least 90% (by weight) of the individual fibres have a length within ± 10% of the average fibre length, and thereafter employing that separated fraction for admixture with the agglomerating agent.

16. A process as claimed in any of claims 10 to 15, in which the flax fibre employed as starting material at least partly derives indirectly from harvested flax straw, after retting and/or scutching thereof.

17. A process claimed in claim 16, in which the flax fibres employed are or include the tow and/or shive generated during scutching.

18. A process as claimed in any of claims 10 to 17, in which the average fibre length of the comminuted flax fibre is in the range of from 3 mm to 6 mm.

19. A process as claimed in claim 18, in which the average fibre length is in the range of from 4 mm to 6 mm.

20. A process as claimed in any of claims 10 to 19, in which the flax fibre employed as starting material at least partly derives directly from harvested flax straw fed as such to the comminutor employed, and the thereby-macerated non-fibrous part of the flax straw after gelatinization serves as at least part of the agglomerating agent.

21. A process as claimed in claim 20, in which the average fibre length of the comminuted flax fibre is in the range of from 10 mm to 20 mm.

22. A process as claimed in claim 20 or claim 21, in which the average fibre length is in the range of 10 - 16 mm.

23. A process as claimed in claim 22, in which the average fibre length is in the range of from 14 mm to 15 mm.

24. A process as claimed in any of claims 10 to 23, in which the mixture is formed into discrete particles of at least partly predetermined size and shape by compressing and extruding it through an extrusion die and severing the extruded rods as they emerge to a desired length by means of a guillotine.

25. A process as claimed in claim 24, in which the rate of extrusion of the mixture and the intervals at which the emergent rods are severed are adjusted relative to each other so as to yield disc-like pellets suitable for an industrial end-use.

26. A process as claimed in claim 24, in which the rate of extrusion of the mixture and the intervals at which the emergent rods are severed are adjusted relative to each other so as to yield rod-like pellets for an horticultural, agricultural, animal husbandry or domestic end-use.

27. A particulate material whenever manufactured by a process as claimed in any of claims 10 to 26.

28. A method of improving and/or stabilizing soil in which an area of soil to be improved and/or stabilized against wind and/or water erosion is treated by applying thereto an appropriate amount of the particulate material claimed in any of claims 4 to 9 or 27.

29. A method as claimed in claim 28, in which the particulate material contains comminuted flax fibres having an average fibre length in the range of from 10 mm to 20 mm and has been compressed and shaped into rod-like pellets.

30. A method as claimed in claim 28 or claim 29, in which the particulate material also incorporates plant nutrients and/or grass seed.

31. A method as claimed in any of claims 28 to 30, in which the agglomerating agent in the particulate material is or includes the macerated bark and pith of whole flax straw, gelatinized by application of heat and moisture.

32. A method of animal husbandry in which ruminant livestock are fed with a nutritive feedstuff including flax-fibre-containing particulate material, as claimed in any of claims 4 to 9 or 27, in a proportion such as to supply some or all of the roughage necessary for the digestive well-being of the ruminant animal thus fed.

33. A method as claimed in claim 32, in which the particulate material contains comminuted flax fibres having an average fibre length in the range of from 10 mm to 20

mm and has been compressed and shaped into rod-like pellets.

34. A method as claimed in claim 32 or claim 33, in which the agglomerating agent mixed in with the particulate material is or includes the macerated bark and pith of whole flax straw, gelatinized by application of heat and moisture.

35. A method as claimed in any of claims 32 to 34, in which the particulate material also incorporates nutrients for ruminant-livestock.

36. A method as claimed in claims 34 and 35, in which the agglomerating agent also includes crushed linseed oil-cake.

37. A method as claimed in any of claims 32 to 36, in which the agglomerating agent is or includes tow residues recovered from scutching flax straw, said tow residues being contaminated with traces of a drying vegetable oil.

38. A method as claimed in claim 37, in which the tow residues are contaminated with raw linseed oil.

39. A method of animal husbandry in which ruminant and/or non-ruminant livestock are fed with a nutritionally-enhanced feedstuff including the flax fibre-containing particulate material, as claimed in any of claims 4 to 9 or claim 27, wherein the cellulosic content of said flax-fibre has been at least partially degraded into more

digestible form by treatment with strong alkali.

40. A method as claimed in claim 39, in which the preliminary treatment of the flax fibre to partially degrade the cellulose and thereby enchance the nutritional value of the fibre is effected by incorporating strong alkali into the fibre and tow mix fed to the pelleting operation.

41. The use of the flax-fibre-containing particulate material claimed in any of claims 4 to 9 or claim 27 as toilet litter for domestic animals.

42. Use as claimed in claim 41 in which the particulate material takes the form of miniscule pelleted rodlets having a diameter not exceeding 3 mm and an average length not exceeding 6 mm.

43. The use of the flax-fibre-containing particulate material claimed in any of claims 4 to 9 or claim 27 as an absorbent for industrial oil spillages.

44. Use as claimed in claim 43, in which the particulate material is employed in the form of miniscule pelleted rodlets having a diameter not exceeding 3 mm and an average length not exceeding 6 mm.

45. The use of the flax-fibre-containing particulate material claimed in any of the claims 4 to 9 or claim 27 as a persistent, slow-release particulate solid lubricant.

The Patent Office

Application No:	GB 9505327.8	**Examiner:**	Alexander Littlejohn
Claims searched:	1-46	**Date of search:**	13 September 1995

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Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

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Other: Online: WPI

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
X	GB2272903A	(Puwakdandawe) see whole document, e.g. page 1 line 12, page 6 lines 10-23, page p line 18	1-6
Y	GB2136263A	(BP Nutrition) see whole document, e.g. page 1 lines 26-29	1-6,42,43
X	GB1581281	(Schanze) see whole document, e.g. page 4 lines 16-28	1-6,33,36
X	DE4317185A1	(Thuringisches) see whole document	1-6
Y	US5347950	(Kasbo) see whole document, e.g. col 2 lines 12-22	1-6,29,30, 33,34,42, 43
Y	US4473390	(Teufel) see whole document	1-6,29,30
X	US4258660	(Pris) see whole document, e.g. col 2 lines 29,45,46,56,57	1-6,42,43
Y	US3881024	(Pahoundis) see whole document, e.g. col 4 line 62 - col 5 line 6	1-6,33,34

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
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